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STANFORD RESEARCH INST MENLO PARK CA SYSTEMS EVALUAT--ETC F/G 19/2  
TELEVISION BOMB/ROCKET SCORING SYSTEM: TECHNICAL PERFORMANCE SP--ETC(U)  
JUN 74 M S COLAH, J A CHASTAIN N60701-74-M-7082  
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SYSTEMS EVALUATION DEPARTMENT

⑨ Technical Note  
⑭ SED-TN-669

⑥ TELEVISION BOMB/ROCKET SCORING SYSTEM:  
TECHNICAL PERFORMANCE SPECIFICATIONS.

by

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⑫ 19p.

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RECEIVED  
DEC 13 1978  
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Stanford Research Institute  
Menlo Park, California

⑪  
Original Date: 14 June 1974

Latest Revision:

DISTRIBUTION STATEMENT A  
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Distribution Unlimited

SRI Project 3451  
Contract/Purchase Order No. N60701-74-M-7082

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## I INTRODUCTION

In October 1973, Atlantic Fleet Weapons Range (AFWR) requested that the Naval Air Systems Command (NAVAIR) procure two air-to-ground weapons scoring systems for installation at Targets 1 and 2 on Vieques Island, Puerto Rico.\* After an interim period, during which Fleet Missiles System Analysis & Evaluation Group Annex (FMSAEG) assisted by Stanford Research Institute (SRI) analyzed and evaluated the performance of such systems, FMSAEG was requested by NAVAIR to prepare procurement specification documents for two operational air-to-ground weapons scoring systems specifically employing television.† The intent of these documents is to describe as fully as possible technical and contractual requirements so that prospective contractors can submit responsive bids to construct and install the systems as a turn key effort.

This Technical Note responds to a request from FMSAEG to provide a description of technical requirements, accuracy specifications and an outline of acceptance tests which the systems would be required to undergo before acceptance by the Navy.

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\* Commanding Officer, Atlantic Fleet Weapons Range speedletter; AFWR:712/711:1f, Serial 419, of 19 October 1973.

† Commander Naval Air Systems Command speedletter, 53524A/TRJ; of 28 May 1974.

## II TECHNICAL SPECIFICATIONS

### A. Background

The systems specified here will be used to score air-to-ground delivery training exercises conducted at Targets 1 and 2, Vieques Island, AFWR, Puerto Rico, which are now manually raked. A scoring method using television camera sensors has been selected for this application to obtain the benefits of partial automation of the scoring process, including greater accuracy and consistency and a reduction in the personnel required for scoring.

The two Vieques targets have different geometrical configurations but both can easily be scored by a television system. This performance specification describes the required and desired operational characteristics of the scoring systems. Any feasible television technique may be used to meet the requirements.

### B. Requirements

#### 1. Ordnance

The scoring system must be capable of providing real time impact location information for the types of ordnance used in air-to-ground delivery training at AFWR. The ordnance used will include, MK 76 and MK 106 practice bombs and inert 2.75 inch folding fin aircraft rockets. In addition, it is desirable that the system be capable of scoring the full range of tactical air ordnance, including all sizes of mines, bombs, rockets, and air-to-surface missiles.

## 2. Target Characteristics and Scoring Areas

A detailed geographical description with a map showing Targets 1 and 2 and the usage of adjacent areas for artillery and naval gun fire will be provided by FMSAEG. Only a brief summary will be provided here, with a highlighting of the main points as they affect technical specifications.

Both targets are circular and 500 ft in radius. Present aircraft run-in lines and bunker locations are fixed, except for the location of one of the bunkers. However, it is desired that the scoring systems be adaptable to changes in run-in or camera location. The terrain is hilly and will necessitate the leveling of target #2 (i.e., both targets will be approximately level). Moreover, some of the bunkers are inaccessible except by 4-wheeled vehicles.

Both targets must be capable of simultaneous operation from the Observation Post (OP) at Cerro Matias which will house the display and computing elements as well as the human operators of the two systems. The angles subtended by the camera optic axes at the target center will be about  $64^\circ$  and  $75^\circ$  for targets 1 and 2 respectively, so that scoring computations will differ in the two systems. An unobstructed line of sight from both cameras to all parts of the target area will be possible, and this will apply to both targets.

## 3. Delivery Modes and Characteristics

Weapon delivery will be by VF and VA type aircraft using dive angles between 0 and 60 degrees from the horizontal with release altitudes from 100 to 30,000 feet. Other delivery modes such as toss (low, medium, or high), over the shoulder, pop-up, lay down, LABS techniques and mine laying may be used.

Bombs/rockets may impact the ground at any angle above 5 degrees from the horizontal, at impact velocities between about 100 and 4,000 feet per second, and may ricochet upon impact. Only the initial impact shall be scored.

No modification to any of the delivery procedures shall be required for scoring purposes. It is required that the system be capable of scoring by day or night, and without artificial target illumination using only standard spotting charges in the training ordnance. The system will not be required to score ordnance without spotting charges (for example FFAR), except in the daytime.

#### 4. Scoring Accuracy

For impacts occurring within 50 feet of the target center, the allowable scoring tolerance as reported by the system shall be no more than 5 feet from actual impact. For impacts that occur more than 50 feet from the target center, the allowable tolerance shall be no more than 10 percent of the actual impact distance from the target center.

These tolerances are intended to indicate in a statistical sense, circles (with actual impact point as center) within which the system will score the ordnance dropped, 68 percent of the time (if a very large number of drops are scored). Theoretically, they represent a  $1.5\text{-}\sigma$  circle, assuming that the system has identical random scoring errors in two orthogonal camera directions. (The errors in the two cameras are assumed to be independent and normally distributed with equal standard deviations  $\sigma$ .)

#### 5. Scoring Rate

The maximum scoring rate for bombs/rockets shall be 2 projectiles per minute or a period of not less than 30 seconds. That is, after impact the system must provide a visual display of the score

(and if required also provide a hard copy) for verbal transmittal to the aircraft or the air-traffic controller. The system must be ready to score the next impact 30 seconds after the previous impact. It is desirable that the system be able to score at intervals as short as 15 seconds.

6. Operating Conditions (To be modified, as required by FMSAEG)

The system shall be capable of operating on the site without loss of accuracy under the following conditions.

6.1 Altitude

- (a) Transport to 40,000 feet
- (b) Operating 0 to 10,000 feet

6.2 Temperature

Sensors and exposed equipment:

- (a) Storage, -40°C to 80°C
- (b) Operating, 10°C to 80°C

Control Tower Equipment:

- (a) Storage, -30°C to 80°C
- (b) Operating, 10°C to 60°C

Computer and/or peripheral equipment, input/output devices, etc.:

- (a) Storage, -20°C to +85°C
- (b) Operating, 10°C to 50°C

6.3 Relative Humidity

Sensors and exposed equipment, 0 to 100%

Control Tower equipment, 0 to 95%

Computer and/or peripheral equipment, 0 to 90%

6.4 Wind Velocity (unrestricted in direction)

- (a) Nonoperating, 0 to 100 knots
- (b) Operating, 0 to 30 knots

6.5 Weather Conditions (sensors and exposed equipment)

Light rain, or drizzle (up to 0.1 inch per hour), sleet, light fog, and hail. The equipment shall also operate in the salt atmosphere existing at AFWR.

6.6 Time (total system)

Day or nighttime operation without additional artificial illumination.

6.7 Vibration

6.8 Shock

6.9 Fungus

6.10 Radio Frequency Interference

Serious consideration must be given to the earliest practical stages of design and development so that the generation of radio interference by the equipment and the vulnerability of the equipment to radio interference shall be satisfactorily controlled.

The equipment shall operate satisfactorily in a military environment containing many types of electronic equipment. In order to ensure compatible operation, the equipment shall be designed so that it is free of spurious and unnecessary radiation and it shall not be susceptible to the reception of unwanted or unneeded energy. Specifically, any radiating or receiving elements utilized as part of the scoring system shall be compatible with existing avionics and/or communication equipment carried in all Navy tactical airplanes. In addition, those avionics and communication systems which are required for range safety must function normally in conjunction with the scoring system instrumentation when the latter is operating in its normal training mode.

The design of the scoring system shall ensure that properly authorized radiations from equipment external to the scoring

system do not degrade the latter's capability and conversely that radiations from the scoring system do not interfere with properly authorized receiving equipment external to the scoring system.

Scoring systems employing the radiation of electromagnetic energy shall employ only frequencies authorized for such use, or for which an official application for such authorization is pending.

## 7. Operating Characteristics

### 7.1 Operators

Each target scoring system must be capable of operation by no more than one trained operator corresponding approximately to the level of an Electronics Technician Third Class (ETN3). All system functions such as turn on, calibrate, computer selfcheck to ensure software/hardware integrity, reset, sensor score, system shutdown, and interfacing with other input/output devices shall be capable of activation by the operator from a single operating position.

### 7.2 Calibration

Each operator must be capable (without any other assistance) of manually initiating and completing calibration procedures during the daytime or at night. These procedures shall be as simple and straightforward as possible and shall functionally test the complete system including sensors, telemetry links between sensors and control tower, command and control circuits, computer operation (including all the normal encoding/decoding functions, etc.) printer, and display. The display and printout during calibration shall show the errors (if any) in each of the sensors; the subsequent operational scores shall include a correction based on the most recent calibration results. The complete calibration procedure shall take not more than 10 minutes.

### 7.3 Data Format and Display

Impact location shall be determined (in terms of distance and direction from target center) and available for relay to the aircraft making the drop. Both down range-cross range (x-y) and clock code scores shall be available by operator selection. Scores shall be displayed in easily visible alphanumeric characters and shall be recordable as an option on paper or magnetic tape,\* with the range time code and run number associated with each score. The printout shall also include other system commands such as system on/off, calibration results, etc., as and when these are carried out. An interface shall be provided to allow direct plotting of impact locations by conventional x-y plotter.

Any other printouts or computer memory dumps shall be in normal decimal or alphanumeric notation, i.e., the operator or range personnel shall not have to convert binary code to decimals.

### 7.4 Location of Cameras

The cameras used to determine impact location shall be placed at least 1000 feet from target center and shall be both adequately protected from ordnance impact or flying debris and capable of being camouflaged so as to be invisible from normal delivery profiles. The Navy will provide structures suitable for housing and mounting the cameras and will also provide security features for their protection. Camera air-conditioning, if required, installation, alignment, and so forth are to be the responsibility of the contractor.

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\* Standard devices such as the commercially available 10 cps ASR-33 paper tape punch/printer are envisioned.

### 7.5 Power

Electrical power will be supplied as GFE to standard electrical panels in the Cerro Matias OP and the bunkers provided for the television cameras. Power will be  $115 \pm 10\%$  V, 60 cycles  $\pm 3\%$  AC. The contractor will advise the Navy of the electrical power demand of the scoring equipment.

### 7.6 Other System Characteristics

- Video information from both cameras of a system will be displayed simultaneously and in real time on the operator display console. A means shall be provided for the operator to enter data from both cameras for the same instant of time, e.g., some means of "freezing" the display at the instant impact is observed or of recording and playing back the video, with a stop action feature to allow scoring the exact impact.
- A digital mini-computer shall be incorporated in the system(s) to perform scoring calculations, establish display formats, etc. The computer shall be capable of interfacing with a hard copy printer and standard x-y plotter, which shall be optional system elements.
- The maximum warm-up time for the system prior to full operation shall be less than 15 minutes. After warm-up and calibration, the system shall meet the accuracy specified in Section B-4 for at least 8 hours before recalibration is required.

- The TV cameras will be remotely activated and deactivated from the operator console and the operator must be able to protect the individual camera vidicons through remote control of an adjustable sun shutter or lens iris, or both.
- Regardless of the means used to insure simultaneous scoring at both cameras, an optional capability to record at least 50 impacts for playback and rescoring shall be offered.
- The design of the system shall incorporate standard off-the-shelf hardware to the maximum extent possible.

## 8. Reliability

### 8.1 General

The scoring system shall operate satisfactorily for a minimum of 5000 hours without major overhaul under the conditions (or any reasonable combination thereof) specified under 3.0. (A major overhaul means the system is required to be down for more than seven working days.) This criterion shall be met with a 95% confidence level.

The equipment shall be deemed to operate satisfactorily if:

- (a) More than 68% of the scores given by the system lie within the accuracy specifications given in Section II B-4. Any tests designed to verify satisfactory operation shall use a sample size consistent with detecting percentage differences (from the design goal of 68%) of at least 5%, with the following constraints:

- (1) Type I<sup>\*</sup> error (level of significance)  
to be 10%
- (2) Type II<sup>†</sup> error to be no more than 30%.
- (b) The number of scores that the system fails to score  
do not exceed 5% of the total sample size selected  
in (a).
- (c) Delays from improper equipment operation or failure  
in operation do not exceed one minute.

### 8.2 Operating Life

The system shall have a minimum total operating life of 35,000 hours with reasonable servicing and replacement of parts with a 95% confidence level.

### 8.3 Maintainability

Mean time to repair shall be 30 minutes commencing upon the range technicians' access to equipment. The intent here is that the range shall be restored to the performance defined in this specification within a mean time of 30 minutes following a failure.

The manufacturer shall specify the manpower and the technical level of competence required for routine service as well as major repair to the system. He shall also specify the amount and nature of spares to be kept on hand for minor repairs as well as major overhauls.

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\* A Type I error is the probability of concluding (from experimental data) that the scoring system is inaccurate when in fact it is accurate. (Accurate, meaning that 68% or more of the scores given do lie within the accuracy specifications given.)

† A Type II error is the probability of concluding (from experimental data) that the scoring system is accurate when in fact it is inaccurate. (Inaccurate, meaning that less than 68% of the scores given lie within the accuracy specifications given.)

8.4 Documentation

This section to be provided by FMSAEG.

8.5 Training

This section to be provided by FMSAEG.

### III ACCEPTANCE TESTS

Upon delivery of the system the Navy will require formal acceptance tests to verify that the provisions of this specification are met. These tests will be performed at the operational sites, i.e., Targets No. 1 and No. 2, Vieques Island, with the system(s) completely installed and operated by Navy supplied operators.

The Acceptance Tests will be performed in accordance with an Acceptance Test Plan provided by the Navy and under the direction of a Test Director designated by the Navy. The Acceptance Test Schedule will cover a period of six weeks. During the first two weeks, commencing at the time system installation is completed, the contractor may operate and test the systems at will, using his own personnel, to insure that it is properly adjusted and ready for acceptance testing by the Navy. The Navy will provide a presentation of up to 200 simulated impacts (using the devices described below) at each target, located within the target areas as desired by the contractor. Up to one-quarter of the simulated impacts may be provided at night, if desired. In addition, the Navy will arrange for the firing of a total of up to 50 inert 2.75 inch aircraft rockets at the two targets. Also, during this period the Navy's designated system operators will be provided instruction in the operation and calibration of the system, including the opportunity to score both simulated and actual impacts.

At the end of the first two week period, the systems will be made available to the Navy for accuracy verification tests, to be conducted over a two week period. During this test phase the Navy operators will operate the systems and the Navy test crew will conduct the tests under

the direction of the Navy Test Director. The contractor may have observers at the tests and will provide the services of an engineer and operator thoroughly familiar with the systems to perform any maintenance, adjustment, or repair requested by the Test Director.

During the third two week period the Navy will use the system for normal scheduled training exercises to verify its suitability and reliability. The contractor will make available the services of an engineer and operator familiar with the systems to assist in resolving any problems that may arise.

During the entire test period a detailed log of system performance will be kept; the log will also be used for notation of all routine calibration and adjustment and any failures or corrective maintenance. Written Failure Reports will be submitted by the contractor for any corrective maintenance required. Any failure deemed to be major by the Test Director may, at the option of the Navy, require restarting the test phase in which the failure occurs.

The detailed Acceptance Test Plan will be provided to the contractor at the time the systems are delivered to the operational sites, or sooner. To permit proper planning by the contractor, however, the principal features to be incorporated in the acceptance tests are described below.

- The Navy will provide and employ impact simulation devices that electrically detonate the standard MK 4 Mod 3 smoke cartridges at presurveyed points within the designated scoring areas. These devices have been determined to provide a realistic simulation of the impact of MK 76 and MK 106 practice bombs. Statistically valid samples of simulated impacts will be scored in the areas within 50 feet of target center (for each target) and also in

the areas from 50 to 500 feet from target centers. The samples of simulated impacts will be uniformly distributed throughout the appropriate areas unless it appears that the system configuration selected by the contractor makes it likely that system error will not be uniform over the scored areas. In this latter case, a statistically valid sample of simulated impacts will be allocated to each portion of the scored area deemed to possess unique error characteristics.\*

- Statistically valid sample sizes are defined to be sufficient to give 90 percent confidence that the system will give errors no larger than the specified values 68 percent of the time, with the Type II error not exceeding 30 percent. The sample size selected will also be consistent with detecting percentage differences (from the design goal of 68%) of at least 5%. See Section II B-8.1.
- A reasonable number of actual 2.75 FFAR impacts will be scored during daylight hours to verify system capability to score these weapons with acceptable accuracy. As time and circumstances permit, actual MK 76 and/or MK 106 impacts may be scored to check on the adequacy of the impact simulations and to explore any differences in operator performance.

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\* For example, should the geometrical relationship of TV cameras to scored areas result in distinct areas of significant geometric dilution of precision (GDOP), separate samples would be used in these areas. Or, should the contractor's selection of camera lenses raise the possibility of excessive lens distortion near the periphery of the scored areas, samples would be adjusted to allow investigating this effect. In addition, separate samples will be used for night impacts.

- Procedures will be incorporated in the Test Plan to verify warm-up time, stability of calibration, achievable scoring rates, freedom from electromagnetic interference, and operation under varying temperature and weather conditions.
- The adequacy of the features provided for interfacing with a hard copy printer, standard plotter, and standard video recorder (recording both videos for split screen display and stop action playback) will be tested.